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(54) IMPROVEMENTS IN AND RELATING TO REINFORCED
 AND LAMINATED PANELS MADE FROM PLASTICS
 MATERIAL

(71) I, MAXWELL ALVIN EARL RHIANDO a British Subject, of 1 Sherbourne Drive, Windsor, Berkshire, and formerly of 11, Vincent Road, Stoke D'Abernon, Cobham, Surrey, do hereby declare the invention for which I pray that a Patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to reinforced and laminated panels made from plastics materials. Such panels are particularly suitable for use in building for decorative and/or structural purposes.

Laminated plastics panels are frequently reinforced with glass-fibres or asbestos and such panels are made by moulding techniques using male or female mould parts together or separately. The use of moulding techniques renders the panels so produced expensive owing *inter alia* to high moulding costs and high release agent costs. Known reinforced panels possess a disadvantage that, when exposed to weather, capillary passages form between the fibres of the reinforcement and a resin binder. To overcome this

disadvantage it is common practice to employ a protective surface coating made from a resin. The protective coating is applied to the appropriate face of the mould and, in order to prevent the coating cracking in service, a surface tissue may be incorporated.

It is an object of this invention to provide a reinforced and laminated panel which is weatherproof and fire resistant and which can be manufactured using vacuum forming techniques. A laminated panel in accordance with this invention may be readily pigmented to form a colour-stable panel.

According to this invention a method of making a reinforced and laminated plastics panel, comprises bonding a particulate, fibrous or stranded reinforcing material to at least a part of one side of a layer of thermoplastics material, applying to the layer of reinforcing material (e.g. to impregnate and coat the reinforcing material) a composition containing a thermosetting plastics material and curing or allowing the said composition to cure whereby at least a mechanical bond is formed between the thermoplastic layer and the so applied layer of thermosetting material through the

agency of the reinforcing material. The layer of thermoplastics material may be pre-formed to any required shape by, for example, vacuum forming prior to lamination.

5 The surface of the thermoplastics layer may be etched using an etching solvent or coated with a thermosetting resin adhesive. In addition to the reinforcing material contributing towards the ultimate strength of the laminated panel, the reinforcing material also serves to provide a mechanical key between the layers of thermoplastic and thermosetting materials which are normally incompatible.

10 The reinforcing material may be one or more of a number of materials, for example, ceramic materials such as calcium silicate, sand, steel, hessian, jute, asbestos, aluminium and carbon. Certain of these materials may be in one or more of the forms mentioned above. In the case of particulate materials, particles having a mesh size within the range of 60/120 mesh are preferred. Where the material is used in fibre or staple form, fibres or staples of length within the range 15 $\frac{1}{8}$ inch to 4 inches are preferred. If desired the reinforcing material may be formed as a separate layer which is applied to the layer of thermoplastics material and bonded thereto under heat and pressure.

20 The thermoplastics layer may be made from any type of thermoplastics material, for example, vinyl chloride polymers and copolymers in plasticised or rigid form, olefin polymers, such as high and low density polyethylene and polypropylene, acrylonitrile-butadiene-styrene copolymers, methyl methacrylate polymers and copolymers, polystyrene, polyethylene terephthalate, 25 methyl pentine polymers, fluoro carbon polymers, polycarbonates, nylon polymers or polyamides, acetal copolymers, phenoxy resins, acrylic polymers and cellulose nitrate and acetate depending on the weathering and chemical resistance the panel is required to withstand in service. This layer of thermoplastics material may have any convenient thickness, for example from 10 to 250 thousandths of an inch. Where it is necessary to produce large panels of material adjacent smaller panels may be seam or solvent welded either before or after lamination in accordance with this invention.

30 The layer of thermoplastics material may contain UV stabilisers, anti-static agents and pigments and a metalised coating may be used where the basic material is clear.

35 The layer of thermosetting plastics material may be made, for example, from epoxy cement materials, thermosetting phenolic and amino resins or combinations thereof capable of curing at room temperature using catalysts and/or accelerators.

40 The invention also includes laminated

panels made in accordance with the methods outlined above.

Various forms of the invention will now be described by way of example.

According to one form of the invention 70 a glass fibre polyester cured laminate impression of the correct size and shape is taken from a master, small holes $\frac{1}{32}$ in diameter are then drilled at the lowest points of the impression which is then 75 placed in a vacuum forming machine. Solid surrounds are placed around the impression and a thermoplastic sheet having a thickness of 0.001 to 0.200 inch is then placed over the impression which also covers the 80 surround. A clamping ring is then placed on top of the thermoplastic sheet to make an airtight seal and then a heater unit is placed in position over the thermoplastic sheet and removed when the sheet is soft. 85 Air is then evacuated from the underside of the thermoplastic sheet which draws or pulls the sheet on to the impression. The now formed thermoplastic sheet is left to cool and harden and is removed from the impression. Any method of vacuum forming 90 can be used in addition to that previously described, for example, assisted vacuum forming, drape forming, drape forming with bubble pre-stretching, assisted blow 95 forming. All these techniques can be used individually or in any combination. The formed thermoplastic sheet is then placed face down on a flat table and an etching solvent is sprayed thereon to assist bonding of the reinforcing material to the thermoplastic sheet. Alternatively the solvent may be replaced by a resin/adhesive coating and the reinforcement in particulate, 100 fibrous or strand form is spread over the coating which is then allowed to dry. Various reinforcing materials are mentioned elsewhere in the specification and these form a mechanical key for the resin binder, which will adhere to the so-roughened surface of the thermoplastics material 105 when cured. The thermosetting composition which can for example be a urea resin with a minimum 60% to 80% solids with a hardener such as an ammonium salt incorporated, is then brushed or sprayed over the reinforcing material forming the mechanical key. Further reinforcing material such as glass fibre or asbestos may be placed on top of the already applied composition and 110 further quantities of the thermosetting composition are applied to saturate the reinforcing material using a stippling brush or roller which can either be used manually or mechanically, working the composition 115 (sometimes referred to as resin binder) into the reinforcement which in turn contours the reinforcement to the shape of the thermoplastic sheet. The composition may also be sprayed on to the reinforcing material. 120 125 130

Thereafter the laminated panel is left to cure at room temperature, or at an elevated temperature sufficient to increase the setting time without deforming the formed thermoplastics layer. The reinforcement may be glass fibre or asbestos fibre matt consisting of chopped fibre strands held together with a binding agent, but hessian, jute, cotton, flax and rayon materials or similar, can be used in loose or matt forms. Any of these materials can be used in a continuous strand form which is fed through a shredding machine which in turn sprays the chopped fibres directly on to the resin binder working transversely, if required. The thermosetting composition may be an unsaturated polyester including a catalyst, accelerator and colourant. The thermosetting composition or resins may be an ortho-phthalic or isophthalic unsaturated polyester resin, or water thinnable Portland cement epoxy, epoxy resin, phenolic resin, or amino resin. It is preferred that these resins are thermosetting forms and cured using catalyst or accelerators or both. The resin binder may contain fire agent additives in those resins which are inflammable.

It may be preferred to make the protective coated laminate more rigid when in sheet form and sheet materials such as plywood, asbestos, chipboard, plaster-board and compressed straw, or any foam material with an additional layer of thermosetting resin saturated reinforcement on top of the foam, which are cut to the size of the laminate can be placed on top of the laminate prior to curing which subsequently bonds to the laminate. Preferably absorbant materials are used so that any solvent or water can be absorbed into the sheet backing material, thereby enabling a faster cure to take place.

The preferred reinforcements are glassfibre or asbestos consisting of chopped fibre strands held together with a binding agent, but hessian, jute, cotton, flax and rayon materials can be used in loose or mat form. Any of these materials can be used in a continuous strand form which is fed through a shredding machine which in turn sprays the chopped fibres directly onto the partly formed panel, if required.

The reinforced sheet or shaped panels produced by this invention are produced more cheaply than by conventional methods in that no moulds are required, no release agents are required, no mould preparation or extraction is required, no gel coats or surface treatments are required. Further, the laminates according to this invention are produced more quickly than hitherto because any air entrapment on the surface of the laminate, which otherwise would affect the quality of a conventional laminate and would therefore require experienced opera-

tors does not matter.

The following is a description by way of example of methods of bonding reinforcing material in the form of fibres or staples made of glass to one surface of various thermoplastic sheet materials. The glass fibre preferred is manufactured in a continuous filament and wound into a cheese for convenience of handling. The cheese is then placed next to a moving conveyor fitted with an endless heat resistant conveyor belt ready for feeding into a device for cutting the glass fibre into short lengths not exceeding four inches. The cutting device consists of a metal tube or roller sleeved with rubber. Fitted directly above the rubber faced roller is another metal roller fitted with cutting blades attached around the circumference, and spaced apart at a convenient distance depending on the length of fibre or staple required. When one end of the continuous filament is fed into the cutting device, the cutting roller is rotated in an anti-clockwise direction and the rubber roller is rotated in a clockwise direction thereby cutting the filament into the desired length as the cutting blades sink into the roller by breaking the filament at that point of contact. The short staples are then continuously spread in a random but substantially even layer onto the moving conveyor belt. The width of the cutting device determines the width of the prepared glass fibre layer.

Other methods of preparing the glass fibre layer for bonding to the thermo plastic sheet to achieve the same result may be used. For example, the glass fibre layer may be applied directly onto the selected treated thermo plastic sheet material forming a moving base carried for example by a belt conveyor.

Vinyl chloride polymer sheet materials:—
The glass fibres are applied in a random layer of 1 oz. per sq. ft., up to 8 oz. per sq. ft., in weight onto the conveyor belt. At a convenient distance from the cutting device, the glass-fibre layer is compacted by passing it between nip rollers which may be heated (up to two hundred and fifty degrees Centigrade., for P.V.C.). After compacting, polyvinyl chloride in self-sintering powder form is deposited onto the top of the glass fibre layer by fluidised bed techniques or a blow or spray gun mounted for traversing the width of the glass fibre layer or deposited from a fixed central position and distributed by electro statics distribution. Alternatively, the powder may be discharged from an outlet slot in a storage hopper which may be vibrated to assist discharge and which is positioned above the glass fibre layer. This method may also be distributed by electro static methods. The

quantity of vinyl chloride powder applied is sufficient to cover the immediate glass staples forming the top face of the glass fibre layer but not coat more than fifty per cent of the glass staples contained in the glass fibre layer. The amount of vinyl chloride powder may vary from quarter of an ounce to eight ounces per sq. ft. It is also preferred that each glass staple on top of the glass fibre layer is also coated completely with the vinyl chloride powder. To assist the coating, the glass fibre layer may pass through a heater unit prior to applying of the polyvinyl chloride powder so as to melt the powder which flows around each glass staple on the surface. Alternatively the polyvinyl chloride may be sprayed in liquid form i.e. plastisols or organosols on top of the glass fibre layer which may be heated. An aqueous binder solution may be applied to the glass fibre layer prior to passing between the nip rollers which holds the glass staples firmly together when compacted and retains sufficient tack to hold the deposited layer of polyvinyl chloride in powder or liquid form. All polyvinyl chloride in solution form may be applied by spray or curtain applications. The amount of polyvinyl chloride in liquid form may vary from quarter of an ounce to eight ounces per sq. ft. based on the weight of the vinyl chloride.

When the polyvinyl chloride has been applied on top of the glass staples, the glass fibre layer passes through another set of nip rollers which may also be heated up to hundred and sixty degrees cent., for P.V.C., which compacts the glass fibre layer and levels the treated glass staples on top of the glass fibre layer, which can then be rolled up producing a random treated glass fibre mat. The glass fibre mat can now be bonded on to all types of polyvinyl chloride sheet by heat laminating the treated glass fibre side on to the sheet material. As the pressure of heat is applied the polyvinyl chloride bonded to the glass staples softens, and bonds the glass fibre mat to the polyvinyl chloride sheeting material. The treated glass fibre layer can also be pressed into the sheet material as it comes out of an extruder or calendering machine and pressed in whilst the sheet material is still hot which in turn softens the polyvinyl chloride bonded to the glass staples of the glass fibre mat until the sheet has cooled. It may be preferred to use a co-polymer such as vinyl chloride/acetate co-polymer for application to the glass staple instead because the co-polymer has a lower softening point and requires less heat to bond the glass fibre mat to all types of vinyl chloride sheet materials. This method also stops the glass fibre mat from marking the sheet material during bonding (particu-

larly for plasticized vinyl materials) on the other face of the sheet material. Clearly, there are other similar plastic or rubber materials for bonding a glass fibre mat to a vinyl chloride sheet in rigid, plasticised or co-polymer form using the methods described.

Polyolefin polymer sheet materials:— the preferred sheet material polyethylene e.g. high density polyethylene and polypropylene which are in pressed, extruded or calendered forms. The method of bonding used for the polyolefine sheets is the same for the vinyl chloride polymer sheet materials, but the materials for treating the glass staples of the glass fibre layer differ. The preferred materials in powder form may be the same as for the polyolefin sheet materials, or alternatively the powder materials may be different for example — a polyethylene powder can be used in the treatment of the glass staples and provide the bond to the high density polyethylene or polypropylene sheet materials. Liquid solutions, for example of co-polymers based on polyethylene may also be used to bond the glass fibre layer to the polyolefin sheet materials. The quantity of powder or liquid to be applied to the glass staples may vary from quarter of an ounce to eight ounces per sq. ft., and may not coat more than fifty per cent of the glass staples contained in the glass fibre layer which can vary in weight from one ounce to eight ounces per sq. ft. When the glass fibre mat has been prepared it can then be laminated on to any polyolefin sheet material or directly pressed into the hot calendered or extruded polyethylene or polypropylene as it emerges from the extruding or calendering machine as previously described for vinyl chloride sheet material.

Acrylonitrile-butadiene-styrene copolymer sheet materials:— All sheet materials based on acrylonitrile-butadiene-styrene copolymer (a.b.s.) are suitable in extruded, pressed or calendered form. Laminated sheet materials such as acrylic or polyvinyl chloride faced a.b.s. are also suitable. The method of bonding is the same as for polyvinyl chloride, but may also include other powder or liquid treatments for bonding the glass staples to the a.b.s. sheet materials. For example:— polymethyl methacrylate or polystyrene powders or liquids using varying temperature ranges from a hundred to two hundred and eighty degrees cent., depending on the type of powder or liquid polymer used, may be used for coating the glass staples of the glass fibre layer and bonding to the a.b.s. sheet materials. The quantity of powder or liquid to be applied to the glass staples may vary from quarter of an ounce up to eight ounces per sq. ft., and may coat more than

fifty per cent of the glass staples contained in the glass fibre layer which may vary in weight from one ounce up to eight ounces per sq. ft. When the glass fibre mat has been prepared it can then be laminated on to the a.b.s. sheet material by passing through heated nip rollers or directly pressed on to hot calendered or extruded a.b.s. as it emerges from the machine as described for polyvinyl chloride materials.

Polymethylmethacrylic sheet materials: All sheet materials based on polymethylmethacrylics are suitable in cast, pressed or extruded form. The method of bonding is the same as previously described, but the preferred materials for treating the glass staples are polyacrylic in powder or liquid form for using at temperatures up to three hundred and twenty degrees cent., for coating the glass staples of the glass fibre layer and bonding to the polymethylmethacrylic sheet materials. The quantity of powder or liquid polymethylmethacrylic to be applied to the glass staples may vary from quarter of an ounce up to eight ounces per sq. ft. and may not coat more than fifty per cent of the glass staples contained in the glass fibre layer which may vary in weight from one ounce up to eight ounces per sq. ft. When the glass fibre mat has been prepared it can then be laminated or pressed on to the acrylic sheet material by any convenient method as previously described.

Cellulosic sheet materials: All sheet materials, based on the cellulosics as a powder or liquid are suitable for bonding the glass fibre layer to the desired sheet material. The quantity of powder or liquid may vary in weight from quarter of an ounce up to eight ounces per sq. ft., and may not coat more than fifty per cent of the glass staples contained in the glass fibre layer which may vary in weight from one ounce up to eight ounces per sq. ft. The methods for coating the glass staples and bonding the glass fibre layer to the desired sheet material are the same as for polyvinyl chloride materials.

Polystyrene sheet materials: All materials based on polystyrene as a powder or liquid are suitable for bonding the glass fibre layer to polystyrene extruded or pressed polystyrene sheet using a powder or liquid version of the sheet material. The quantity of powder or liquid may vary in weight from quarter of an ounce up to eight ounces per sq. ft., and may not coat more than fifty per cent of the glass staples contained in the glass fibre layer which may vary in weight from one ounce up to eight ounces per sq. ft. The methods of coating the glass staples and bonding the glass fibre mat to the polystyrene sheet materials are the same as for polyvinyl chloride materials.

Polyethylene terephthalate / methyl pentine

polymers: All materials based on polyethylene terephthalate or methyl pentine polymers are also suitable for bonding the glass fibre layer to these materials in sheet form using a powdered or liquid form of the polymer or an adhesive form. The quantity of powder, liquid or adhesive may vary in weight from quarter of an ounce up to eight ounces per sq. ft., and may not coat more than fifty per cent of the glass staples contained in the glass fibre layer which may vary from one ounce to eight ounces per sq. ft. The methods of coating the glass staples and bonding the glass fibre mat to the polyethylene terephthalate and methylpentine sheet materials are the same as for polyvinyl chloride materials but using a higher temperature range varying from two hundred degrees cent., up to four hundred degrees cent.

Fluorocarbon polymers / polycarbonates: All materials based on these high temperature polymers as a powder or liquid are also suitable for bonding the glass fibre layer to these materials in sheet form which may also include woven reinforcements in the sheet material such as — glass, Terylene (R.T.M.) or cotton, and using the same methods as for polyvinyl chloride. The quantity of liquid or powdered bonding material may vary in weight from quarter of an ounce up to eight ounces per sq. ft., and may not coat more than fifty per cent of the glass fibres contained in the glass fibre layer which may also vary from one ounce up to eight ounces per sq. ft. The temperatures required to effect the necessary bonds may be as high as five hundred degrees cent., using materials in powder or liquid forms which are the same as the sheet materials. Alternatively it may be preferred to use suitable high temperature adhesives which will achieve the same result.

Nylon polyamides and acetal co-polymers: these materials may also be used as liquid or powder form for bonding the glass fibre layer to these materials in sheet form, which may also contain a woven reinforcement, and employing the same method as described for the polyvinyl chloride sheet materials.

It may be preferred to bond the glass fibre layer on to the sheet material by applying a powder or liquid version of the sheet material to the extruded, calendered, cast or pressed sheet material and either deposit the glass staples in a random pattern on to the treated sheet material or produce a glass fibre mat, and unroll the glass fibre mat on to the treated sheet material. The powder or liquid bonding coat may be applied hot or cold and the glass fibre layer pressed on to the sheet material as it passes between the nip rollers which may

be heated, or alternatively the bonding material may be applied cold as an adhesive and the glass fibre pressed on to the sheet material as the nip roller assists in bonding the mat and forcing the coating around the glass staples which are in contact with the sheet material. Clearly there are many formulations which are compatible with each base material for example rubber-like adhesive coatings which could be used for bonding with each base sheet material.

One method of bonding a thermo-setting resin to the specially prepared formable sheet material will now be described by way of an example. When the glass fibre mat has been bonded to the formable sheet material for example polyvinyl chloride the sheet is passed underneath a device for coating a thermo-setting resin, for example, an unsaturated polyester resin mixed with an accelerator and/or catalyst. The device may be a resin spray unit operating back and forth across the width of the prepared sheet material or a curtain coating unit as for example consisting of a roller which rotates in an anticlockwise direction. Fitted next to the roller is a reservoir containing the polyester resin with the roller fixed on one side of the reservoir and immersed in the polyester resin. An adjustable doctor blade is fitted in the bottom of the reservoir next to the roller which prevents the polyester resin from passing between the roller surface and the doctor blade. When the roller rotates the doctor blade is finally adjusted to allow the polyester resin to form a film thickness on the roller as it rotates by producing a gap between the roller surface and the doctor blade. Fitted directly underneath the roller is another doctor blade which scrapes the polyester resin off the surface of the rotating roller allowing the polyester resin to flow down the surface of the doctor blade and the polyester resin then flows off the doctor blade in a curtain on to the glass fibre mat. The width of the doctor blade determines the width of the thermo setting resin curtain. The coating device can apply any type of thermo setting resin or adhesive which may contain fillers.

The thermo setting resin can also be heated if required in the reservoir. The preferred resin to glass ratio may be from two to one up to six to one for example three ounces of polyester resin to one ounce of glass fibre mat per sq. ft. The compacting of the polyester resin into the glass fibre mat is achieved by using compacting rollers consisting of a series of washers which are spaced apart and which force the polyester resin into the glass fibre mat until there is complete saturation and no air between the polyester resin and the surface of the thermo plastic sheet. Alternatively

a thin plastic foil for example — polyethylene, cellulose or P.V.C. or paper, can be applied on top of the liquid polyester resin and thereafter rolled so as to force out any air between the thermoplastic layer and the layer of thermosetting plastics material. A mesh or continuous strands made of a suitable thermo plastic can also be applied on top of the polyester layer prior to the plastic foil being compressed into the polyester resin if desired. When the thermo plastic/polyester laminate material has been produced, the laminate material can then be formed and hardened into the desired shape by simple heat forming or vacuum forming using male or female moulds. When heat is applied to the thermo plastic sheet layer of the laminate, the sheet material softens and can then be pressed or sucked on to the mould surface which at the same time contours the glass fibre mat and thermo setting resin layer to the formed shape of the thermo plastic sheet. The thermo setting resin can then be allowed to harden to the formed shape at any specified time.

Plug assistance may be used for deep drawing and should always be used on sandwich sheet materials. The thermo plastic /polyester laminate material may also be cured as a flat sheet by passing between low heated platens, each having a polytetrafluorethylene or silicone rubber endless belt fitted. The thermo plastic/polyester laminate may also be semi cured ('B' stage cure) in sheet form and cut into any desired length and heat or vacuum formed in the same way as a thermo plastic sheet. Alternatively, the thermo plastic sheet incorporating the glass fibre mat but without the thermo setting resin applied may be vacuumed or heat formed and then for example an epoxy or polyester resin can be crushed or sprayed on to the preformed glass fibre reinforcement and allowed to cure. Prior to forming of the thermo plastic sheet a layer of plastic foil or mesh can be applied to protect the glass fibre mat against damage.

This invention is particularly useful for bonding together a layer of thermoplastics material and a layer of thermosetting plastics to form a laminate by an intermediate reinforcing layer of inorganic staples which provides a key between the layers and a reinforcement for the laminate. This laminate is also useful where the toughness and rigid properties of a thermo setting resin can improve the much lower tensile properties of a thermo plastic sheet for all mouldable applications.

WHAT I CLAIM IS:—

1. A method of making a laminated plastics panel comprising bonding a particulate, fibrous or stranded reinforcing

material to at least a part of one side of a layer of thermoplastics material, applying to the layer of reinforcing material a composition containing a thermosetting plastics material and curing or allowing the said composition to cure whereby at least a mechanical bond is formed between the thermoplastic layer and the so applied layer of thermosetting material through the agency of the reinforcing material.

2. A method according to claim 1, wherein the layer of thermoplastics material is treated with an etching solvent prior to application of the reinforcing material to assist bonding of the layer of thermoplastics material and the reinforcing material.

3. A method according to claim 1, wherein the reinforcing material is bonded to the layer of thermoplastics material using a thermosetting resin adhesive.

4. A method according to claim 1 wherein the reinforcing material is selected from one or more of glass fibre, asbestos, sand, steel, hessian, jute, aluminium or carbon.

5. A method according to claim 2 including applying to the layer of thermoplastics material a mixture comprising an etching solvent and a particulate material such as sand.

6. A method according to any one of claims 1 to 5 wherein the reinforcing material is bonded to the thermoplastics material by means of a binder which is compatible with the thermoplastics material to which the reinforcing material is to be bonded.

7. A method according to claim 6

wherein the said binder material comprises in particulate form the same thermoplastics material as that to which the reinforcing material is to be applied.

8. A method according to claim 7 including heating the binder and reinforcing material so as to sinter the binder and form a reinforcing layer.

9. A method according to claim 6 wherein the binder is a solvent of the thermoplastics material.

10. A method according to claim 6 wherein the binder is a derivative of the thermoplastics material.

11. A method according to any one of the preceding claims wherein the composition containing the thermosetting plastics material includes a catalyst or an accelerator or both.

12. A method according to claim 11 wherein the said composition includes a pigment.

13. A laminated plastics panel when made in accordance with any one or more of the preceding claims.

14. A method of making laminated plastics panel substantially as herein before described.

15. A laminated plastics panel when made in accordance with the method claimed in Claim 1 and substantially as hereinbefore described.

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